2000

NPS MOVES - Entertainment Research Directions (presentation to Georgia Institute of Technology)

Zyda, Michael

NPS MOVES - Entertainment Research Directions

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Outline

Zyda Bio in Book Covers

NRC report & its impact on VR/CG research

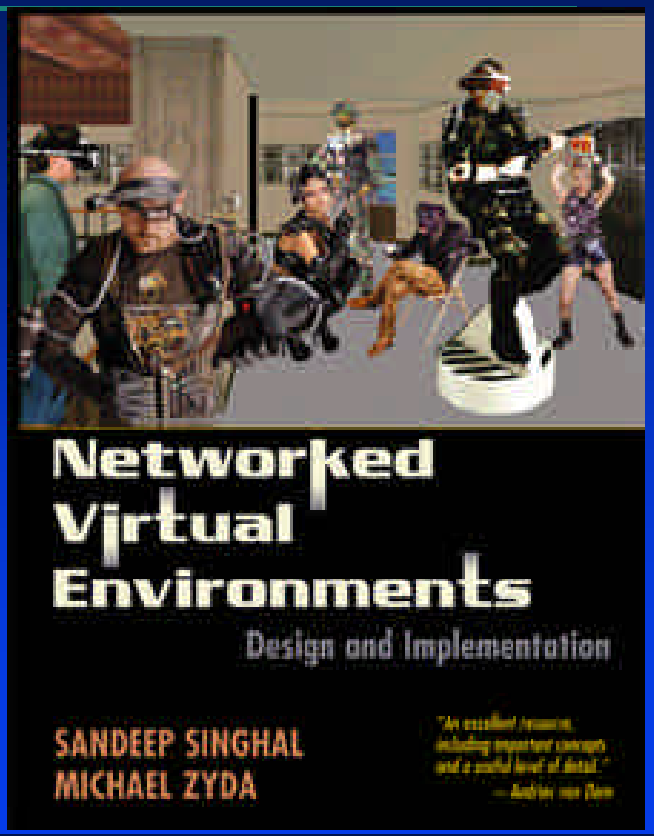
The future of networked entertainment

Research required by entertainment & defense to provide this future

The NPS MOVES Research Center & its Entertainment/Defense Agenda …

Zyda Bio

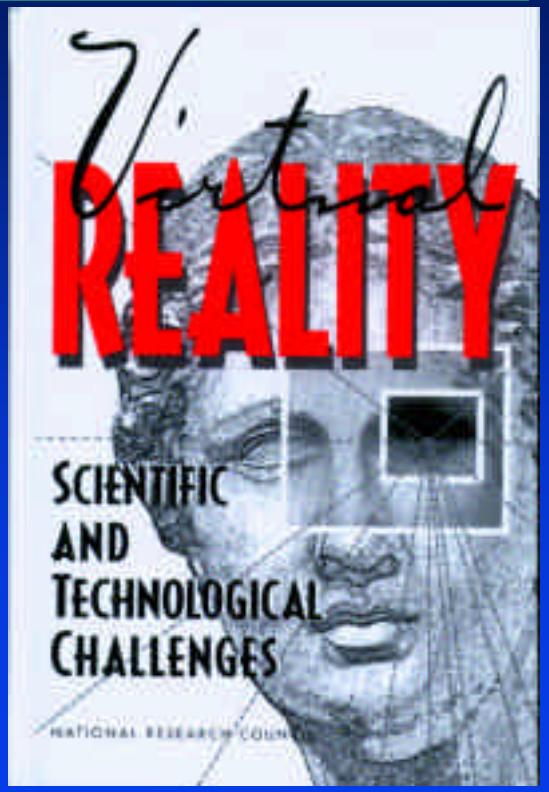
Professor Zyda has directed the NPSNET Research Group at the Naval Postgraduate School since its creation in 1986. His research is on software architectures for large-scale, networked virtual environments.



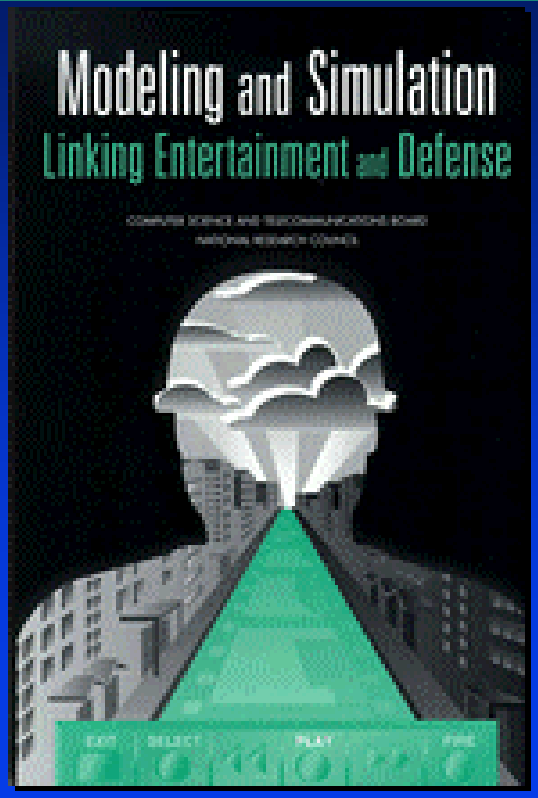
Zyda Bio - NRC 1992 - 1995

NPSNET

Zyda is one of the key authors of the NRC Commission on Behavioral & Social Sciences report "Virtual Reality - Scientific & Technological Challenges"



Zyda Bio - NRC 1996 - 1997



Professor Zyda chaired the NRC Computer Science & Telecommunications Board report "Modeling & Simulation – Linking Entertainment & Defense"

Michael Zyda - NRC 1998 - 2000

NPSNET

Professor Zyda is a member of the NRC Aeronautics & Space Engineering Board Committee on Advanced Engineering Environments, which has produced two reports on how NASA should design space systems in the future (2015), using VEs of course!

So on with the main talk ...

Modeling & Simulation - Linking Entertainment & Defense

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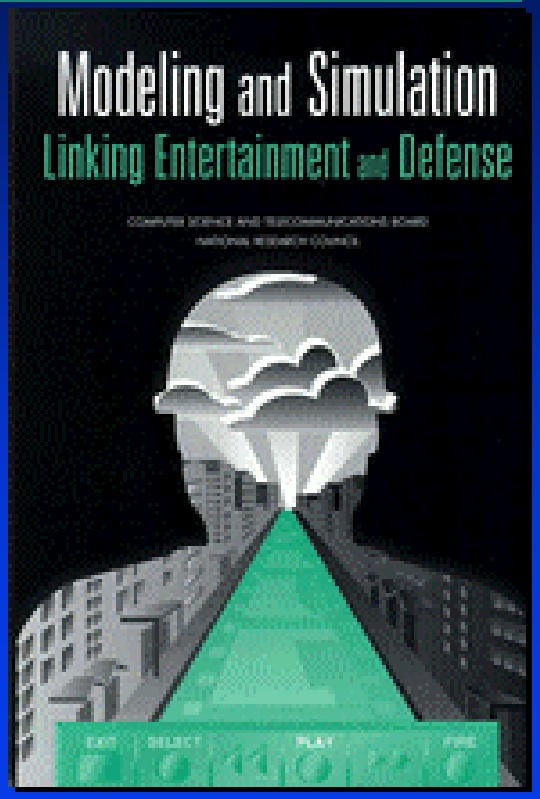
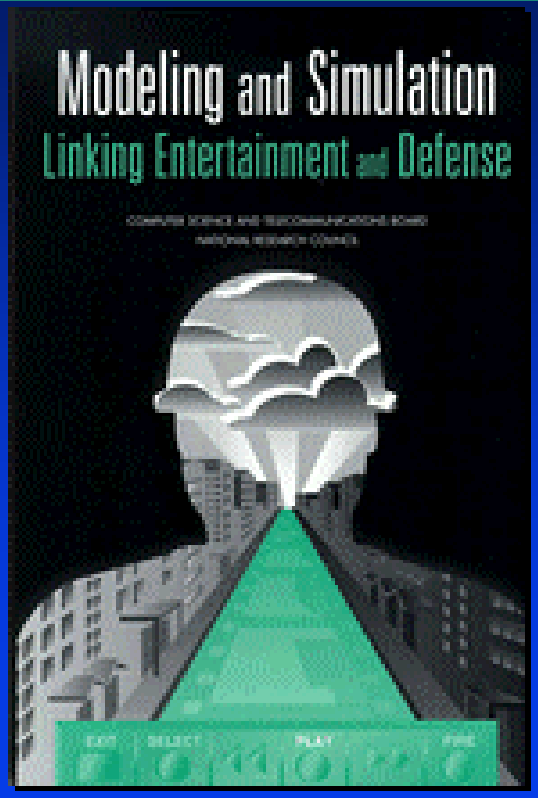
In 1997, the National Research Council issued a report that specified a joint research agenda for defense & entertainment modeling & simulation.



NRC Report



The NRC report provides a guide as to what research & development needs to be done to develop our future interactive entertainment & defense modeling & simulation systems.

Consequences of that report ...

A number of research laboratories have followed the lead of that report & have developed a joint entertainment/VR or entertainment/defense or entertainment/NASA focus.

NRC Research Agenda

Networked Virtual Environments

Standards for Interoperability

Technologies for Immersion

Computer Generated Characters

Tools for Creating Simulated Environments

New Educational Paradigms

The future of networked entertainment ...

In order to understand these research directions, we need to imagine the future of networked entertainment ...

- What do these entertainments look like?
- How do people interact with these systems?

In the future we will have ...

Let's make some assumptions.

- Infinite bandwidth to the home.
- Infinite 3D graphics capability & computing power in the home.
- Affordable for the home.

If this were so, what would our games and IE systems be?

Scenarios derived from today – best we can do ...

- Interactive TV - chattin' with Julie...
- 3D Avatar Chat & RPG - persistent worlds, GangsOnline, SaveThePrincess, SlayTheBeast ...
- Quake/Shooters 2007 - "smell the blood" (the Nth version of this very special shooter ...)

If this were so, what would our games and IE systems be?

- Interactive Dance! - sweat across the 'Net!
- ExtremeSports 2015! - the word Extreme is rapidly becoming a cliché but what the heck!
- MartialArts Forever! - at least its not MaritalArts.

Interactive TV

NPSNET

INTERACTIVITY – chat, change story direction, body tracking to reach out and touch something/somebody, say something, be a part of something …

Video

Interactive TV

GRAPHICS - composited video or just plain video

Two-way audio.

- Maybe Interactive TV understands what we say back & changes the story autonomously?

Interactive TV

'Net – to carry the streams …

- Video/audio stream and entity information to the player.
- Entity interactions and video/audio stream back.

Interactive TV

NPSNET

EXPERIENCE - is this individual or group?

- How did I do with respect to people in the room with me?
- How did my friends perceive I did in this experience?
- Want both ...

3D Avatar Chat & RPG

NPSNET

INTERACTIVITY - We want to have a 3D avatar, with animated face and we want to chat with others or with autonomous characters over the 'Net ...

3D Avatar Chat & RPG

NPSNET

GRAPHICS - Our graphics are going to have to be very good.

- We want to see the lips move on the character to whom we are speaking …
- This has to be synched with the sound …
- Movements cannot lag.

3D Avatar Chat & RPG

'Net – the 'Net is going to have to let us chat/play with people who are located just about anywhere …

- We have audio and entity streams transiting the net.

3D Avatar Chat & RPG

NPSNET

EXPERIENCE - We are going to be a knight fighting the giant, our body motions tracked.

3D Avatar Chat & RPG

NPSNET

EXPERIENCE - We are going to build our own virtual world and interact with our neighbors.

Video

3D Avatar Chat & RPG

NPSNET

EXPERIENCE – We are going to:

- Create an endless variety of characters and families
- Follow a wide range of career paths
- Make friends, have conversations, insult neighbors, fall in love, have children ...

Quake/Shooters - 2007

NPSNET

INTERACTIVITY - We are going to go into a dark, 3D world and fight monsters off the 'Net.

- We're going to hear them breathe and we're going to hear them die.

Our 3D worlds will be rich in detail, with both lighting and texturing and geometry ...

Quake/Shooters - 2007

NPSNET

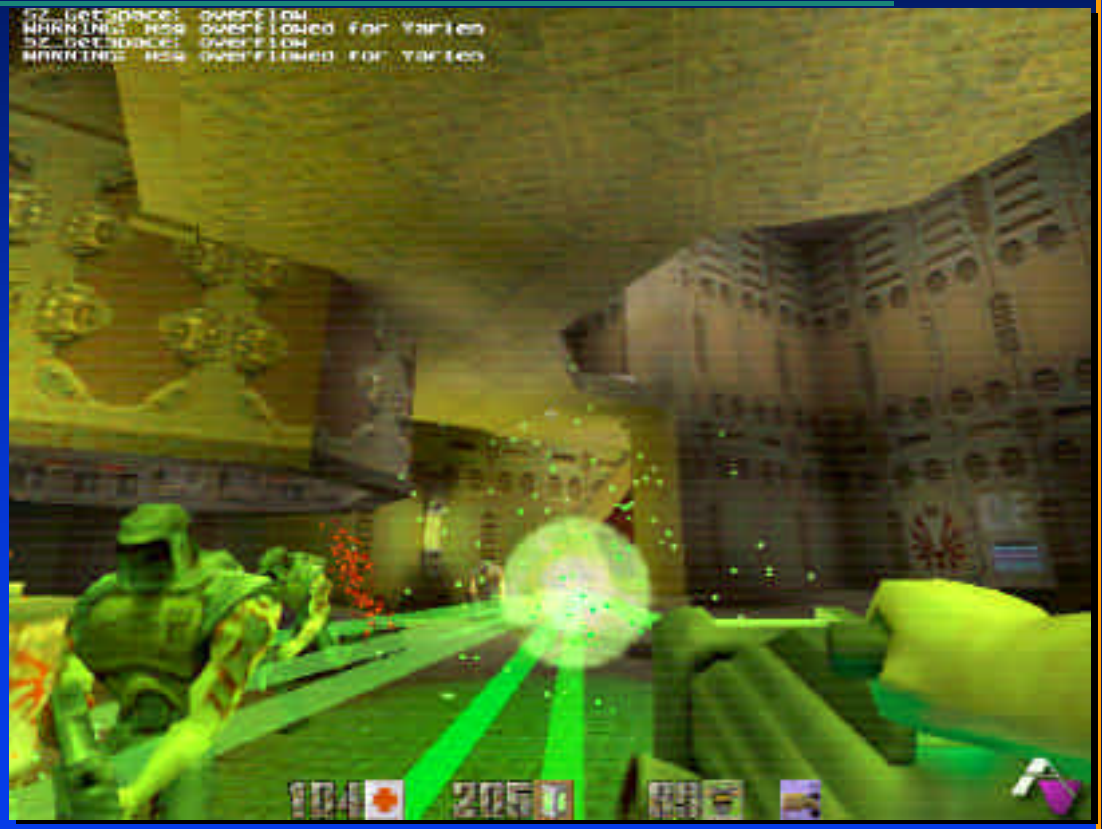
GRAPHICS - Our 3D VE will have fully articulated monsters, monsters steered by body-suited, armed opponents or computed autonomously.

Quake/Shooters - 2007

NPSNET

'Net - We are going to team with distant friends to accomplish our missions.

- We will have an audio stream and an entity stream.



Quake & Shooters - 2007

NPSNET

EXPERIENCE - We will smell the fear of our GameFriends in our dark shooter world.

Interactive Dance

NPSNET

INTERACTIVITY - We dance with our partner on our VR-Stage. We dance with others, whose avatars are coming to us across the "Net.

Interactive Dance

GRAPHICS - Our body movements are tracked and our avatars are responsive.

Interactive Dance

'Net – Our demand will be for premium Quality of Service and we will insist on minimal lag.

- We will have entity streams for our distant partners and audio streams for conversation.

Interactive Dance

EXPERIENCE - A sweaty, 3D fully immersive Karaoke future.

ExtremeSports 2015!

INTERACTIVITY - Imagine the view from the wrestler we will have and the thuds against our body as we perform ExtremeSports from the safety of our VR room.

ExtremeSports 2015!

GRAPHICS - Our worlds will be rich in surface detail and there will not be a missed mogul in its depiction.

ExtremeSports 2015!

'Net – The lag on our 'Net will be so low that we will be able to perform the most delicate motion.

EXPERIENCE – We will be Pele

…

MartialArts Forever!

NPSNET

INTERACTIVITY - the tracking of our body movements in the VR cell will allow us to practice moves against fearsome opponents ....

MartialArts Forever!

GRAPHICS - the human avatars will be incredibly detailed, with each articulation smooth and the skin textures real.

MartialArts Forever!

'Net – lag will be near zero as our Quality of Service is set to Premium. We will feel that fist from Washington, DC ...

MartialArts Forever!

EXPERIENCE – we will be in touch with our inner soldier and those out on the 'Net too …

Commentary on Content - Games of the Future

Now clearly if we are building games like these, there is much new technology to be developed & we hope that there is perhaps better content at some point in time.

- We will still be building shooters in 2015 but we hope that we will also be able to do different & better things, with more wider appeal.
- Certainly we wish to develop IE systems of interest to girls & young women sometime in the next millennium, perhaps where the interaction is more at the psychological level rather than at the physical level, as most of our current games ...

So if we want to be able to develop such IE systems, what do we need?

Hardware, network, software, input devices ....

- Compute power - as many cycles as we can get for under $500. 1,000 Mhz soon to 300 Ghz by 2015!
- Graphics - we are seeing game machines that are claiming 66M textured polygons per second this year. We will have 200M+ to 5B textured polygons per second in three to five years.

Network

We are seeing high-speed nets to the home ….

- You can easily buy DSL now in the US & get 1.5Mbps downstream and 384K bps back.
  - I can interact with 500 players in a game AND have a video stream to my home with such a speed.
  - My home can do a measured 7Mbps to the Internet with DSL! Games with 3,000 players!

Network

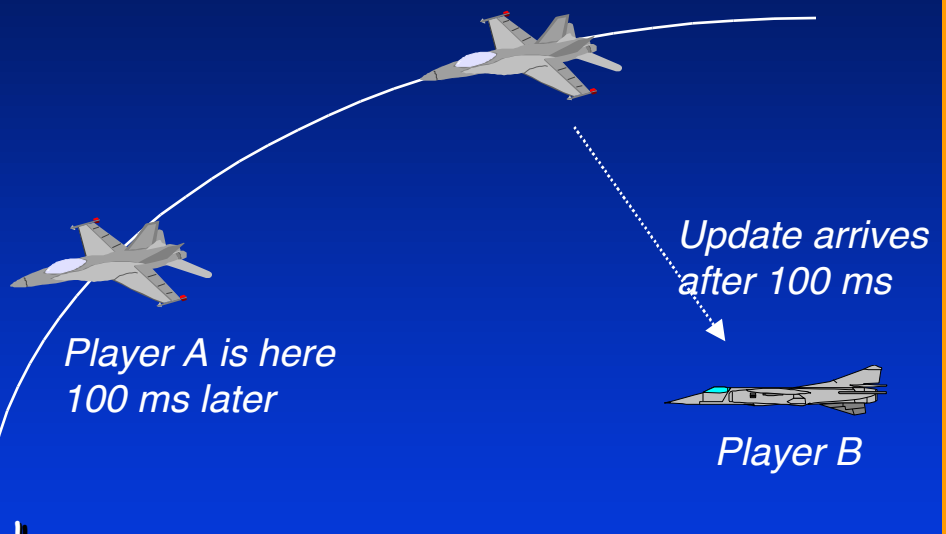
Cable modems?

- These are being deployed more rapidly and the promised speeds are GREAT but the shared nature of the LAN for some areas is distributing poor performance across a large number of users …
  - If we could keep the speeds up per household, then we can support games of 4,000 players and a video stream to the home (10M bps)!

Network Latency

Latency - must be less than 100ms for high interactivity, maybe 200ms for some gaming apps. We are seeing people live with 350ms or greater for some gaming now (awful)!

- Latency reduction & predictive modeling research are very key to us making usable IE systems …



Network Bandwidth Required

So think of bringing 10 to 100Mbps to the home!

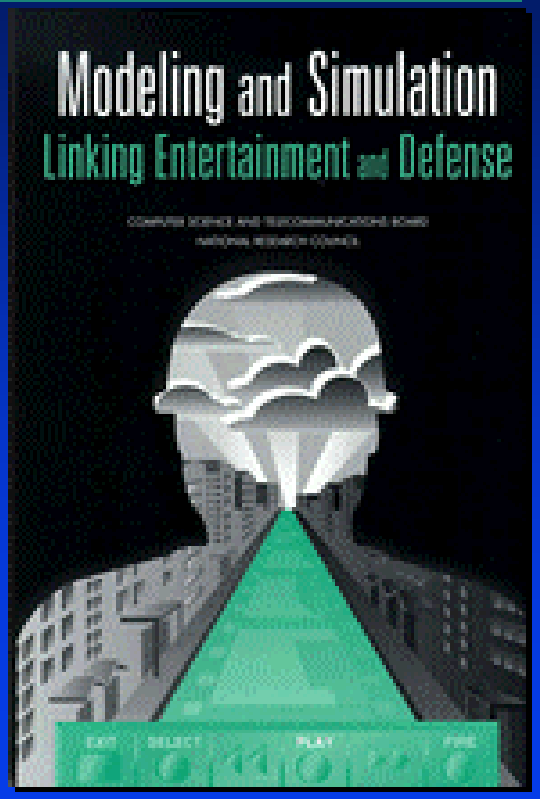
- With such bandwidth, we can easily get to games that support 10K to 50K player games, with audio and video streams.

Think Quality of Service solutions.

Think about how we are going to crush latency EVERYWHERE.

Think the End of the World Wide Wait …

NPS MOVES Interpretation of the NRC Report



The Naval Postgraduate School's Modeling, Virtual Environments & Simulation (MOVES) Academic Program & Research Center has developed a research focus aligned with the NRC report ….

NPS MOVES Research Agenda

Networked Virtual Environments

Standards for Interoperability

Technologies for Immersion

Computer Generated Characters

Human Factors & Human-Computer Interaction

New Educational Paradigms

Networked Virtual Environments - A Vision

Eventually, there will exist a persistent virtual environment simultaneously shared by millions.

There can never be a global reboot.

All modifications must happen on the fly.

The development of participant programs (live & autonomous characters) for that VE must be as simple as writing a web page is today ...

Requirements for that Vision - Network Software Architecture

Extensible/Composable/Interoperable

- Cross-platform, component frameworks
- Dynamic Behavior Protocols

Ability to Suspend/Resume State

- Persistent Universe

Large-Scale/Infinite Number of Players

- Area of Interest Management

NSA Requirements - Extensible, Composable & Interoperable

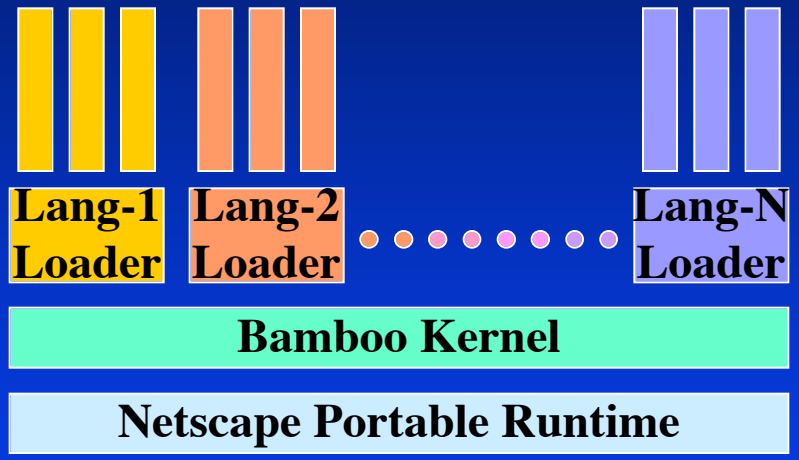
Motivation - Cross-platform, component frameworks

- The motivation behind cross-platform component frameworks is that we want to build systems that are changeable overtime, systems whose updates are downloadable over the Internet, systems that can work on multiple platforms, systems whose pieces are small-enough that they are understandable & reusable.

NSA Requirements - Extensible, Composable & Interoperable

More Than Just Extending Memory

- Dynamically loaded modules require a consistent framework in which to plug into.
- The system must establish a convention such that modules can integrate into already running applications.



Dynamic Behavior Protocols

Desire - each entity in the VE able to define its own protocol modules, modules that are dynamically loadable from the web.

- easy to maintain
- always fully implemented
- always optimized per individual
- never consumes unused system resources
- updateable in real-time!

A Three-Tier Approach Seems the Way to Go ...

Global - An environment registry

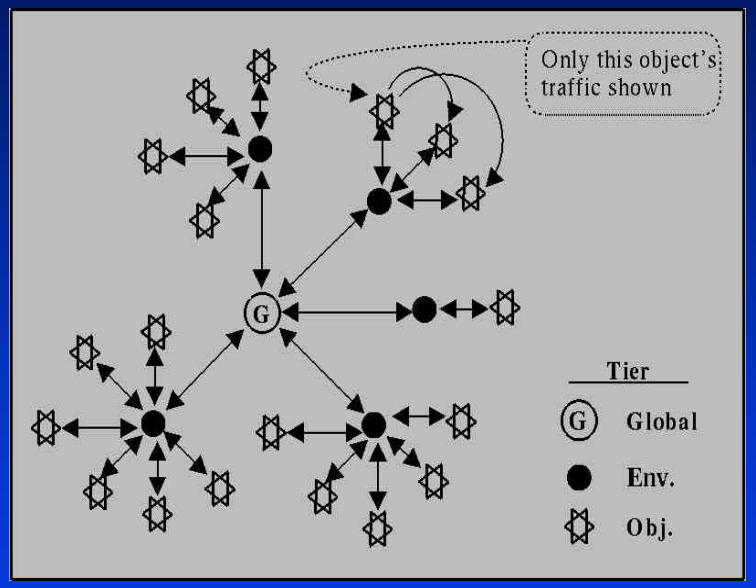
- (help me find an environment i.e. DNS, MAAS)

Environment - An object registry

- (what objects are out there?)

Object - A module registry

- (input/output channels)



A Persistent Universe

Motivation –

- By using dynamic protocols, along with components of the existing Internet architecture, we can support the persistence of a large-scale distributed virtual environment.

http Statelets – A platform independent file containing:

- Names of archived classes
- URLs of the modules containing the classes
- Archived classes

Area of Interest Management - Large-Scale, Infinite Players

NPSNET

Multicast and area of interest managers - to facilitate many-to-many communications while using limited bandwidth.

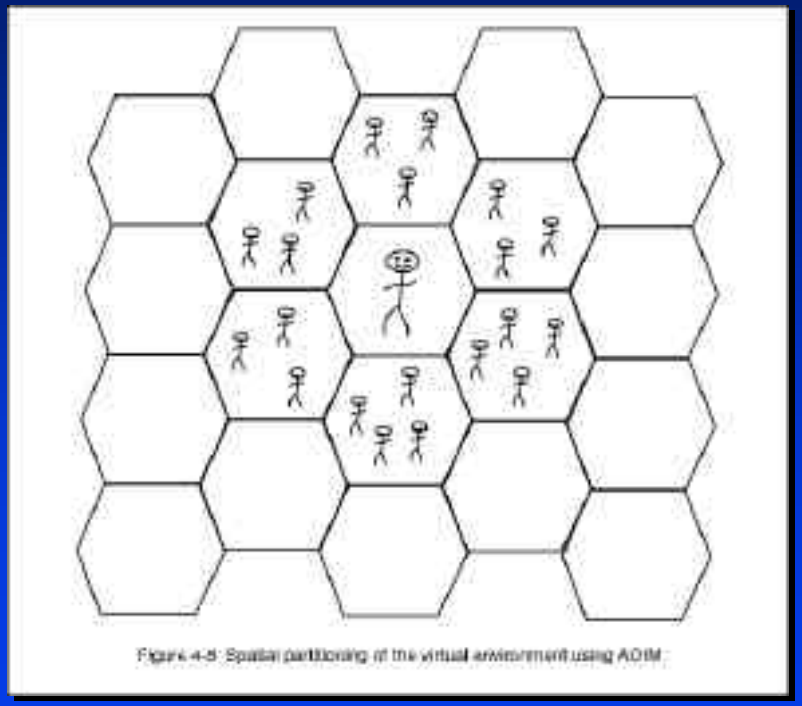


Figure 4-5: Spatial partitioning of the virtual environment using AOIM

4 Keys to Success for Very Large Virtual Environments

Receive only what you need to process.

Must be expandable

- dynamically add new protocols, environments

Must have the ability to handle 'crowd' situations.

Low overhead for interest management.

Interest Management Issues

- Network Latency, Bandwidth
- The time to join a multicast group (0.5 seconds typical)
- Multicast Address Space/Allocation --> IPv6
- Number of multicast groups supported by workstation/PC NICs
- Number of multicast routes supported by network routers.
- Unreliable nature of large-scale multicast --> Need QoS support

Standards for Interoperability

We must be designing standards for interoperability that are as simple to use as writing a web page …

- So once we have done all the net-VE work on the previous slides, we can then think about standardization …

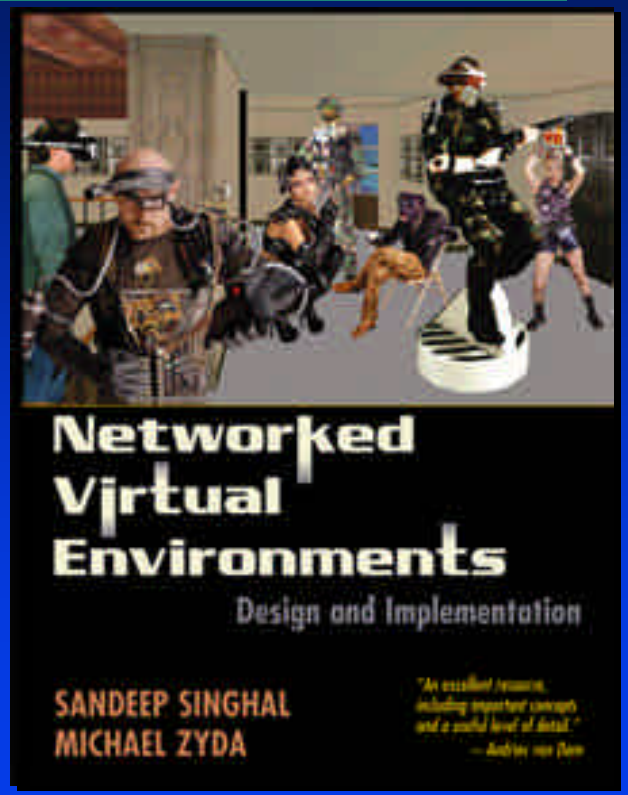
For more information on Net-VEs ...

Sandeep Singhal & Michael Zyda

"Networked Virtual Environments - Design and Implementation,"

ACM Press Books., SIGGRAPH Series., July 1999,

ISBN 0-201-32557-8.



Technologies for Immersion

Image generation - real-time, graphics computers capable of generating complex visual images, novel display devices.

- 1,000 Mhz to 300 Ghz clock rates.
- 200M to 4.8B textured polygon/second.
- GBs of on-board memory.
- Handheld, wireless, sunglasses-like HMDS (game machine platforms!) …
- This is the hardware that is coming …

Trends - Game Machine Platforms

Playstation 2 --> Rasterize 75M polygons/second and transform 66M polygons/second (2 March 2000 in Japan).

Playstation 3 --> 1,000 times faster than that in three years? 66B polygons/second?

- SGI would do 10x in 3 years.

Playstation 2 & Descendents

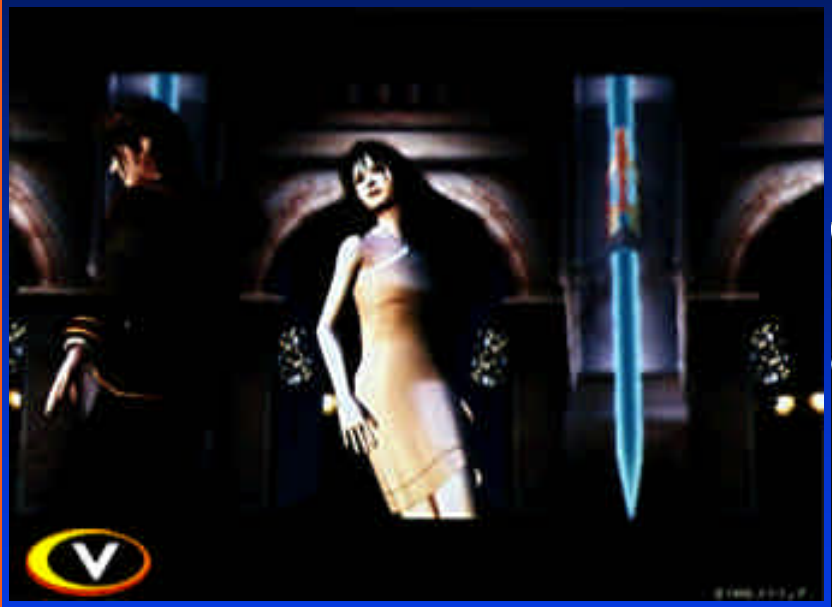
Platform	Polygons/Second	Display Resolution	Availability	Notes
Playstation 2	66M	640 x 480	Mar-00	Emotion Engine & Graphics Synthesizer
				Emotion Engine is the CPU & has 13M transistors
				0.18 micron process.
				$1.1B fab!
				$472M for Emotion Engine fab
				$660M for the Graphics Syn. Fab.
Creative Workstation	10 x PS-2	1920 x 1080/60p	2000	Parallel faster versions
Phase 1	660M?	(progressive)		of Emotion Engine & Graphics Synthesizer
				in Playstation 2.
Creative Workstation	100 x PS-2	1920 x 1080/60p	2002	Emotion Engine 2
Phase 2	6.6B?	24 to 75 fps		Graphics Synthesizer 2
				CPU 40M transistors
				0.13 micron process
				Will be able to handle movie production.
Creative Workstation	1000 x PS-2	4000 x 2000	2005/6	Emotion Engine 3
Phase 3	66B?	24 to 120 fps		Graphics Synthesizer 3
				Radically different architecture
				Server for theaters?
Playstation 3	66B?		2005/6	Based on Phase 3
Reference				
Yoshiko Hara, "Microprocessor Forum: Sony to us Playstation 2 technology for workstation line,"				
	7 October 1999, EE Times			

Visual Reality

Visual reality is 80M polygons/picture [Catmull,1984] & [NRC 95, pg. 252].

- 80M polygons/picture at 60 pictures/second (fps) is 4.8B polygons/second.
- We are talking about machines that can visually display computer images indistinguishable from reality.

Visual Reality

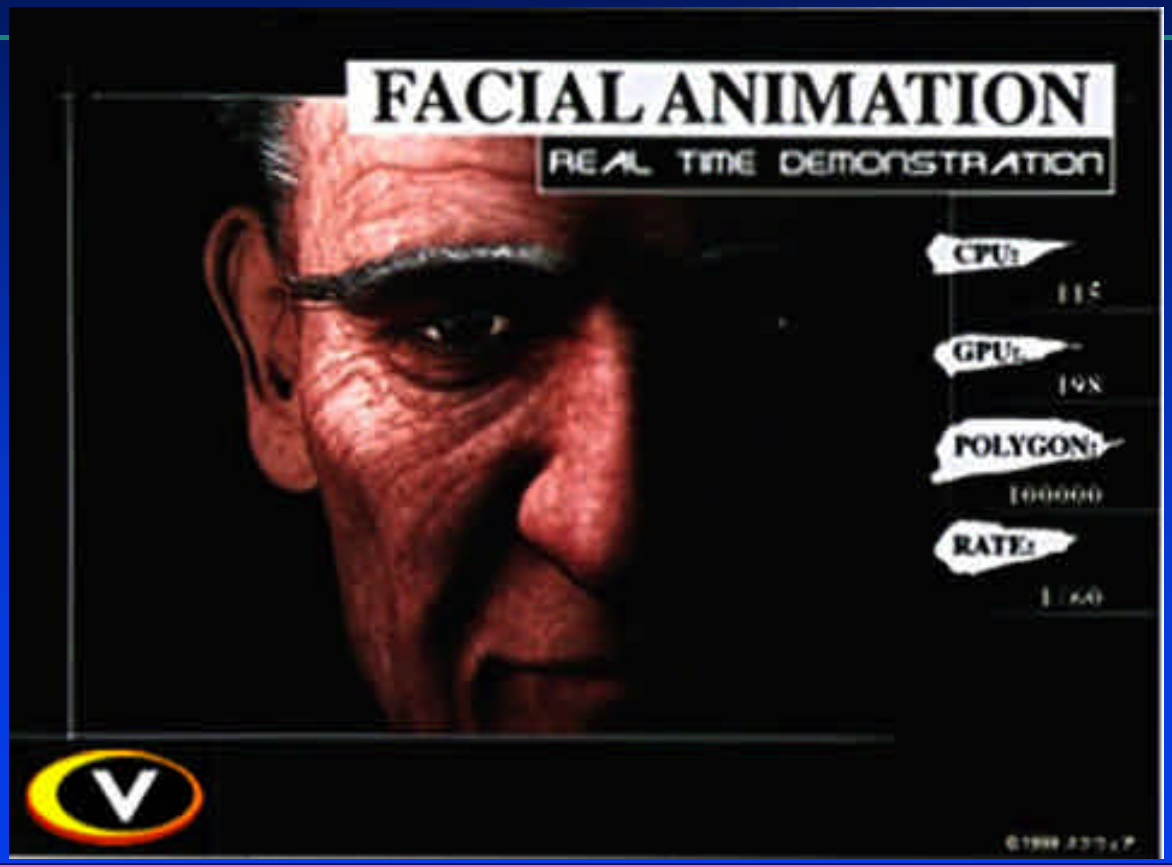


Visual Reality

Video

Video

Visual Reality

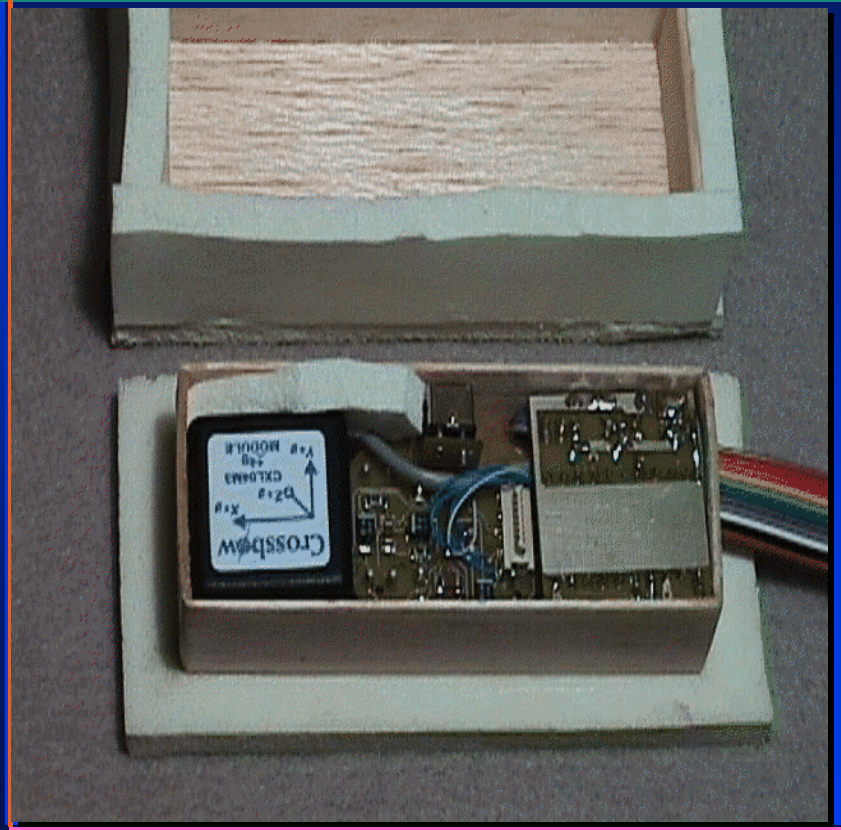


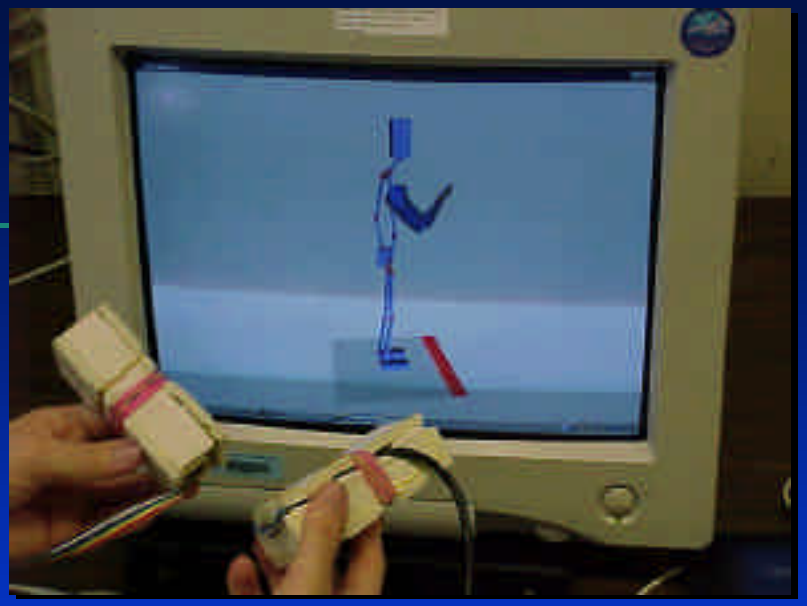
Technologies for Immersion

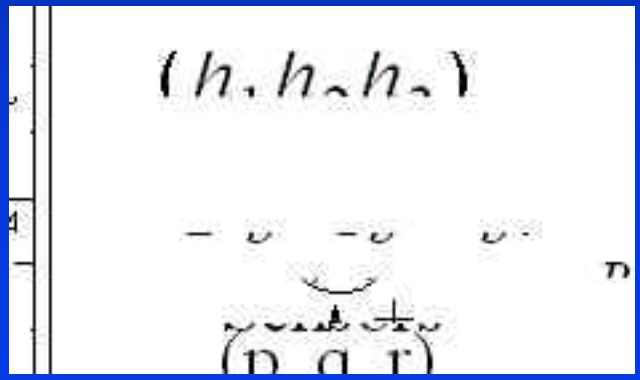
Tracking – technologies for keeping track of human participants in virtual environments.

- We still don't have the trackers we desire!

NPS MOVES
- Inertial Tracker







Technologies for Immersion

NPSNET

Full sensory interfaces

- Technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, & haptic.

Computer-Generated Characters

NPSNET

- We want computer-characters in our net-VEs with whom we can interact in an intelligent fashion.
- We want autonomous behaviors for those characters.
- We want characters that can come in over the network and play with us, educate us, train us, characters that can learn and help guide the VE's story.

Computer-Generated Characters

We need software architectures that can provide:

- Adaptability - modify behavior automatically
- Learning - modify behavior over time, reinforcement learning.
- Agent-based - to allow for emergent behaviors.
- Behavior & Story Modeling
- High quality avatars

NPS MOVES - Projects in Computer-Generated Characters

Networked Agent Architecture

You're in the Army Now! - Recruiting Computer Games

SimNavy Prototype

Networked Agent Architecture

- Develop an NPS-owned agent-based simulation engine.
- Develop an architecture to allow the engine to work in a distributed fashion.
- Develop tools for specifying the interiors & the interactions of the agents.
- All of these are underway & fundamental to their application ...

You're in the Army Now! - Motivation

The motivation of the project is the shortfall in Army recruiting & the potential for improving recruiting through the use of a web-based, instrumented, set of networked videogames.

- Develop an integrated Career and Action game over a span of 48 months, fully instrumented, fully networked, developed for continual content refresh & update, using existing game development technology when possible, developing new technology when necessary.

Two games ...

Career game – focusing on a simulated career, similar to an adventure game where experience through various schools and obtained objects moves you forward in the action.

Action game – similar to Rainbow Six, with the focus on team play.

What is the research here?

We are looking into how videogames can be instrumented to be able to determine:

- Aptitude, leadership abilities & psychological profile.
  - For the Army, we will be able to provide a way of possibly identifying potential recruits & be able to provide strategic communications about the Army.
- We are hoping to expand our work to include a separately funded system (using common architectures) for allowing "kids at risk" to also be able to explore potential career paths ...

SimNavy Prototype - an Enterprise Model of the US Navy

NPSNET

Design a software program called SimNavy to simulate the operation of the Navy. This program will operate in a manner similar to Maxis' SimCity, with a dramatic computer-game interface, but with much higher resolution and Navy-relevant scenarios.

SimNavy Concept

Simulate the OPNAV/N-code operation of the Navy, including:

- Resource allocation
- The psychology of decision making
- The zero sum economy
- Multilateral decisions and constraints.
- The conflict between political process and military requirements.
- The dynamic nature of decision making.
- All assumptions observable and changeable.
- Simulate negotiation, compromises, tradeoffs, frustrations and anxieties of top-level policies.

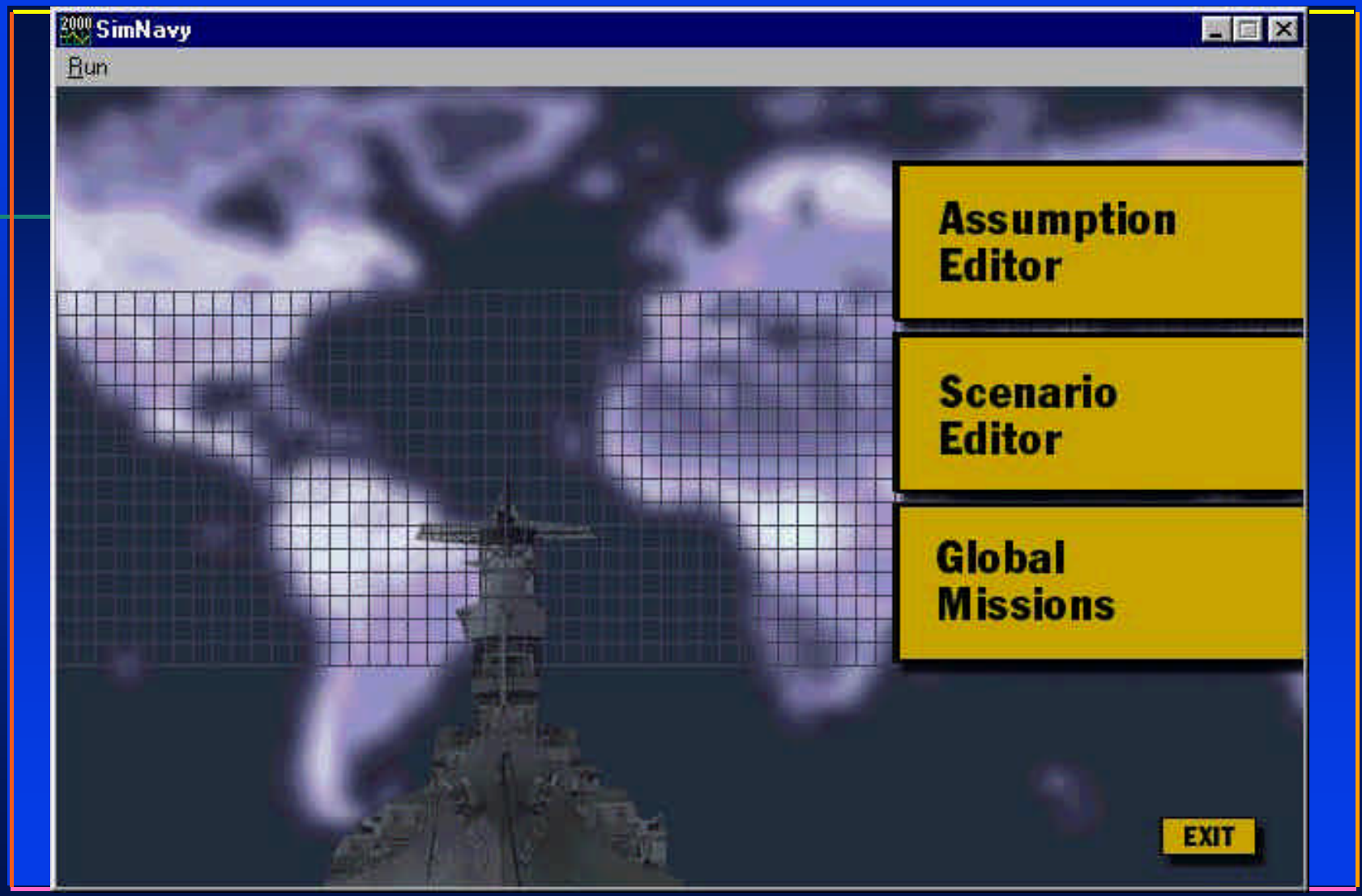
SimNavy Concept continued ...

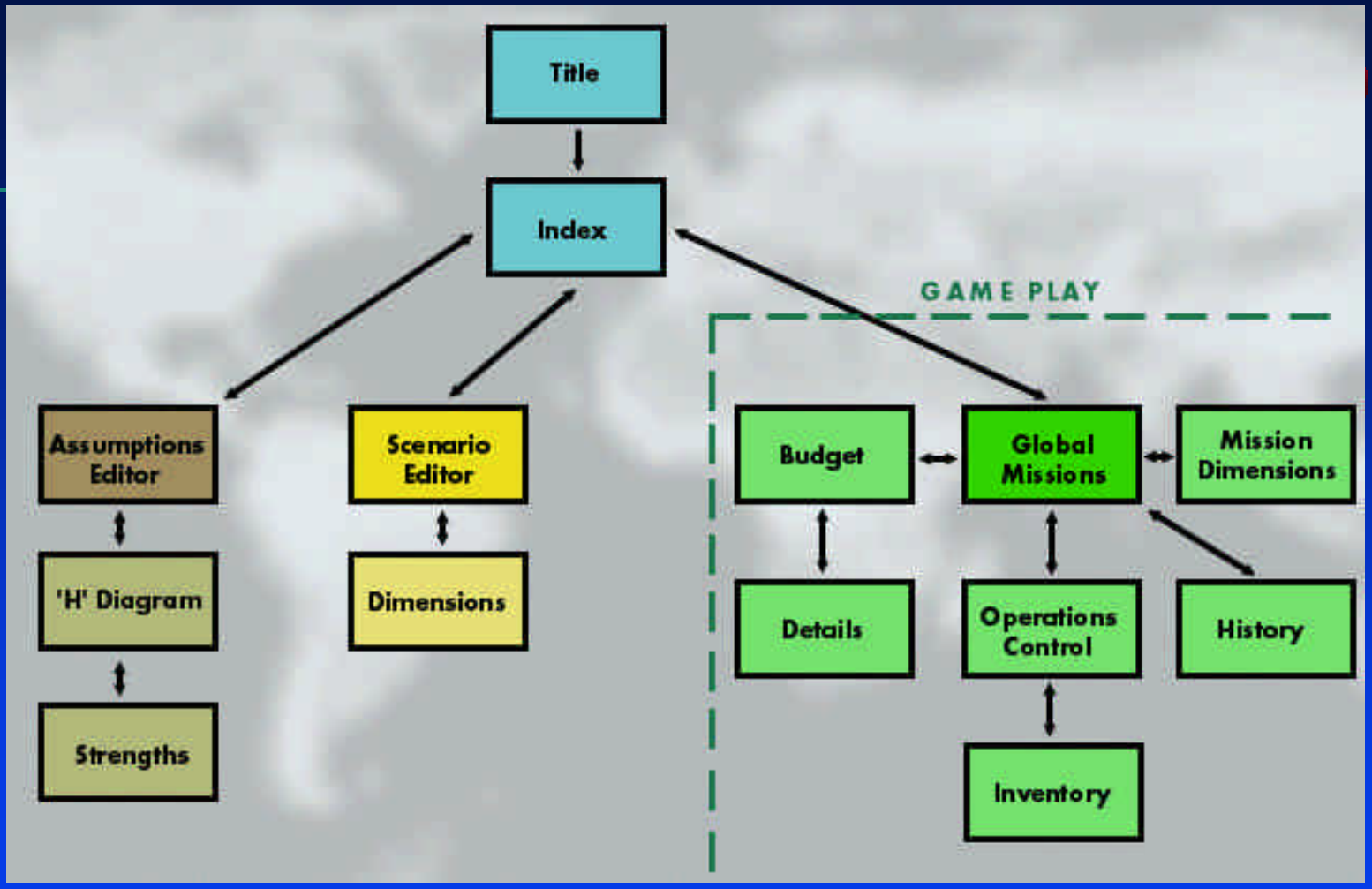
- Expose motives and goals of the decision making process.
- Examine what-if scenarios and alternate outcomes.
- Include the Navy's interactions with the other services and political organizations.
- Provide a high-spark, controversial platform for understanding problem solving in the Navy hierarchy.

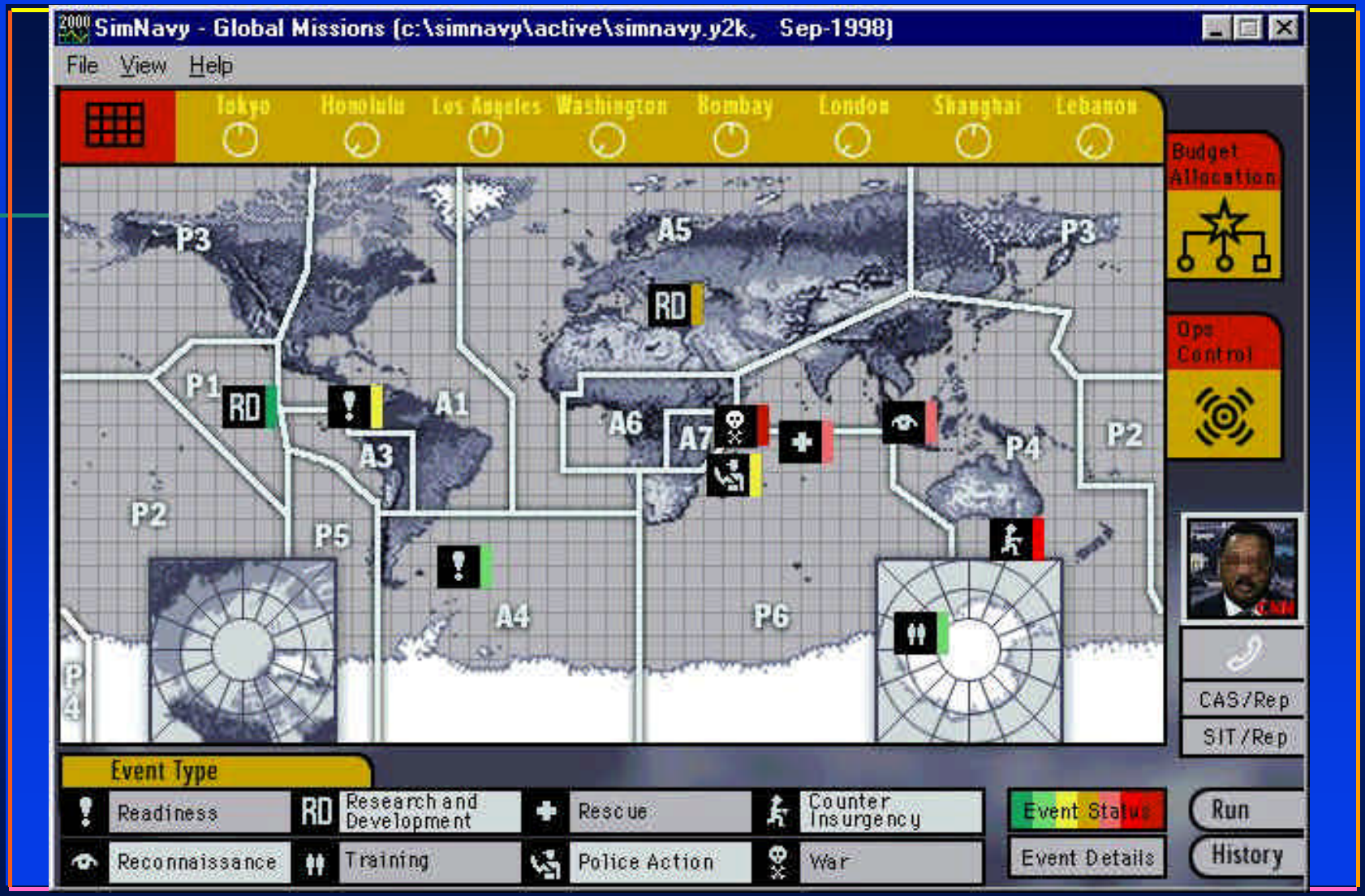
SimNavy's Value

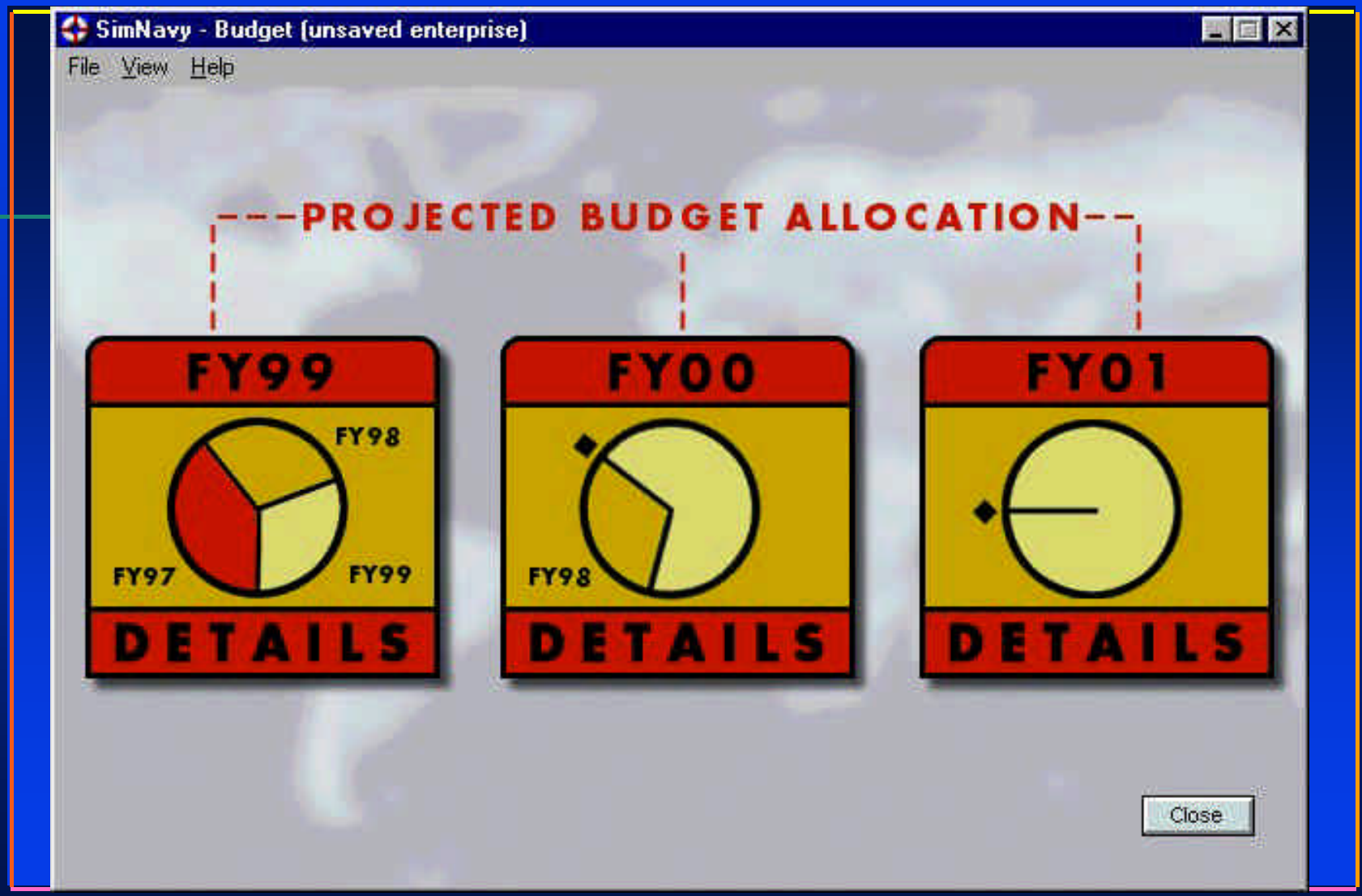
To provide an interactive experience through which Naval officers can learn how to make decisions at the various levels of the Navy's hierarchy.

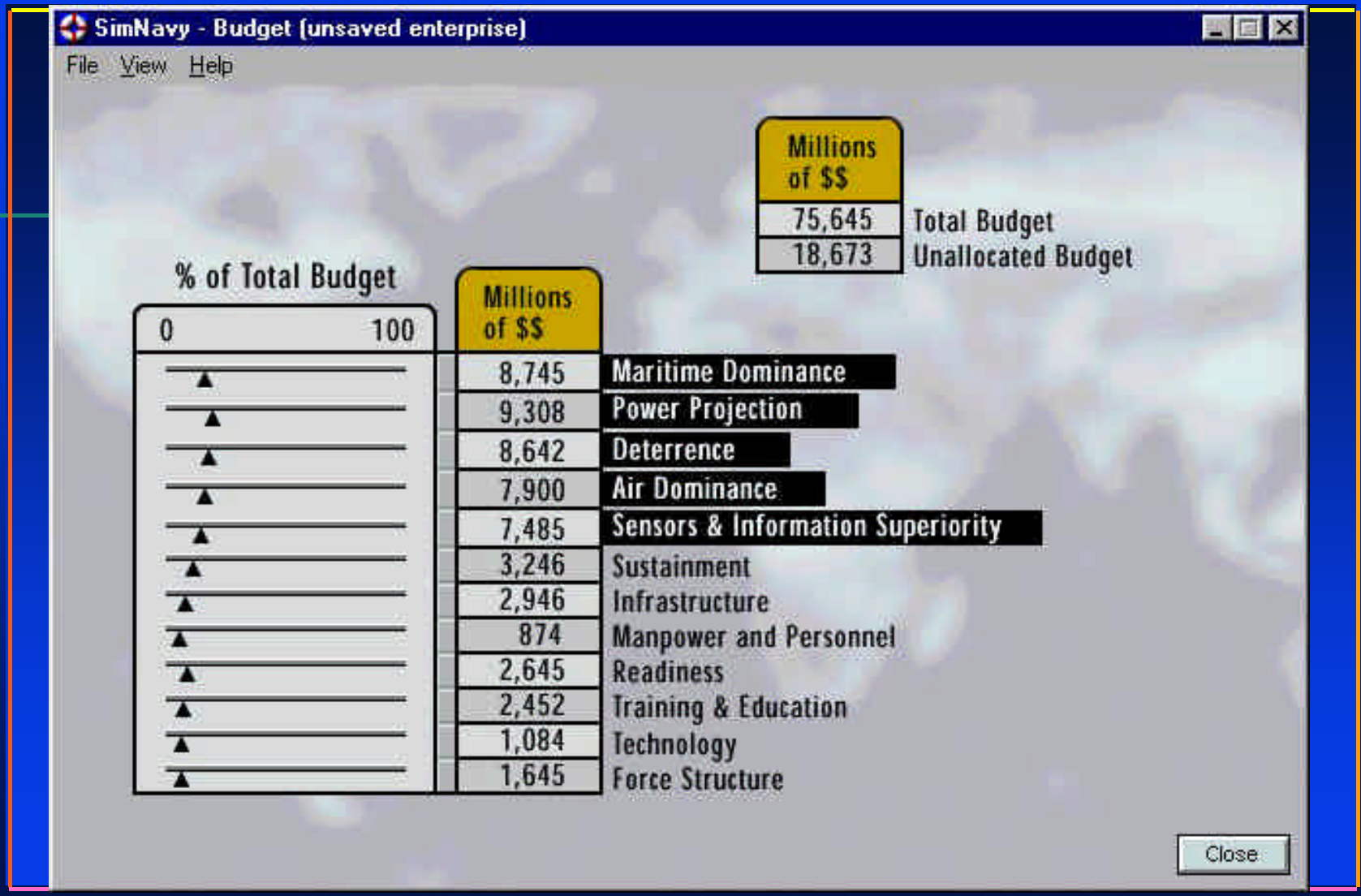
- It should be understood by all that this is not a simulation for Navy war-fighting or tactics but rather a tool to examine the relationship between budget allocation and operational possibilities.


SimNavy
Run
Assumption Editor
Scenario Editor
Global Missions
EXIT


Title
Index
GAME PLAY
Assumptions Editor
'H' Diagram
Strengths
Scenario Editor
Dimensions
Budget
Details
Global Missions
Operations Control
Inventory
Mission Dimensions
History


SimNavy - Global Missions (c:\simnavy\active\simnavy.y2k, Sep-1998)
File View Help
Tokyo
Honolulu
Los Angeles
Washington
Bombay
London
Shanghai
Lebanon
Budget Allocation
Ops Control
P3
A5
P3
RD
P1
RD
A1
A6
A7
P4
P2
A3
P2
P5
A4
P6
CAS/Rep
SIT/Rep
Event Type
Readiness
Research and Development
Rescue
Counter Insurgency
Reconnaissance
Training
Police Action
War
Event Status
Event Details
Run
History


SimNavy - Budget (unsaved enterprise)
File View Help
---PROJECTED BUDGET ALLOCATION--
FY99
FY98
FY97
FY99
DETAILS
FY00
FY98
DETAILS
FY01
DETAILS
Close


SimNavy - Budget (unsaved enterprise)
File View Help
Millions of $$
75,645 Total Budget
18,673 Unallocated Budget
% of Total Budget
0 100
Millions of $$
8,745 Maritime Dominance
9,308 Power Projection
8,642 Deterrence
7,900 Air Dominance
7,485 Sensors & Information Superiority
3,246 Sustainment
2,946 Infrastructure
874 Manpower and Personnel
2,645 Readiness
2,452 Training & Education
1,084 Technology
1,645 Force Structure
Close

NPS MOVES
- New Educational Paradigms

New interdisciplinary academic programs that encompass the field of modeling, virtual environments & simulation.

- Computer Science is only PART of the solution.
- NPS has constructed a prototype educational program based on the NRC report - the MOVES (Modeling, Virtual Environments & Simulation) Academic Group.

Scope of the MOVES Curriculum

Programming

Object-oriented programming, data structures, artificial intelligence, symbolic computing

Systems & Architecture

Computer systems principles, computer architecture, operating systems, distributed operating systems

Computer Graphics

Computer graphics, image synthesis, computer animation, computer graphics using VRML

Mathematical Fundamentals

Multivariable calculus, linear algebra, probability & statistics

Communications & Networks

Computer communications & networks, virtual environment network & software architectures, wireless mobile computing

Virtual Environments

Virtual world & simulation systems, human factors of virtual environments, training in virtual environments

Modeling & Simulation

Stochastic models, system simulation, physically-based modeling, simulation methodology, high & low-resolution combat modeling, modeling human & organizational behavior, agent-based autonomous behavior for simulations

Human-Computer Interaction

Interactive computation systems, human performance measurement, human performance evaluation, human factors in system design, C4I systems evaluation

The MOVES Program's PhD Specialization Areas

Physically-based modeling for virtual environments

Networked virtual environments

Human factors in virtual environments

Adaptable software agents

Modeling human and organizational behavior

Discrete-event systems modeling

Data and model visualization


Any questions?
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